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Mathematical Competitions in Hungary: Promoting a Tradition of Excellence & Creativity

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Abstract: Hungary has long been known for its outstanding production of mathematical talent. Extracurricular programs such as camps and competitions form a strong foundation within the Hungarian tradition. New types of competitions in recent years include team competitions, multiple choice competitions, and some exclusively for students who are not in a special mathematics class. This study explores some of the recent developments in Hungarian mathematics competitions and the potential implications these changes have for the very competition-driven system that currently exists. The founding of so many new competitions reflects a possible shift in the focus and purpose of competitions away from a strictly talent-search model to a more inclusive "enrichment" approach. However, it is clear that in Hungary, tradition itself remains a strong motivating factor and continues to stimulate the development of mathematically talented students. The involvement of the mathematical community in the identification and education of young talents helps perpetuate these traditions.

Keywords: Hungary, mathematics education, mathematics competition, Olympiads, international comparative mathematics education, problem solving, creativity, mathematically talented students.

Introduction

World-renowned for its system of special schools for mathematically talented students, Hungary also has a long tradition of extracurricular programs in mathematics. Extracurricular activities play an important role in the overall education of mathematically talented students (Koichu & Andzans, 2009). Some of the longest-standing extracurricular mathematics activities in Hungary can be traced back to the 1890s and the efforts of Lorand Eötvös (Weischenberg, 1984). The Bolyai Society

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continues to coordinate many of the traditional extracurricular programs established at the end of the 19th century, including the journal KöMaL and the Eötvös Competition (now called the Kürschák Competition), along with several new competitions and programs for mathematically talented students. This article focuses on mathematical competitions in Hungary and reviews recent developments, new competitions, and modifications to traditional offerings over the past twenty years.

Methods

This article is an excerpt from a larger study on the changes in the Hungarian mathematics education system for mathematically talented students over the past twenty years (Connelly, 2010). During the study a series of in-depth interviews were conducted with current Hungarian secondary school teachers, mathematicians, professors, and other educators. Interviews were conducted by the researcher in Budapest, Hungary, with the aid of a native-Hungarian-speaking research assistant when necessary. Commentary on the history, purpose, and impact of mathematics competitions was gathered through interviews with competition directors, organizing committee members, journal editors, and past participants. The interviewees will be referred to as respondents A-U in the remainder of the article.

Historical background information was gathered from sources such as ministry of education publications, mathematical and pedagogical professional journals, and earlier dissertations in the field. Information on competition structures and rules was obtained primarily from each competition's official website and contest documentation. Example problems from a variety of Hungarian mathematics competitions are presented throughout. For larger compilations of Hungarian competition problems published in English, see Berzsenyi & Olah, 1999; Kürschák, 1963; Liu, 2001; and Székely, 1995.

Traditional Competitions

One of the most famous Hungarian mathematics competitions, the Eötvös Competition, is considered "the first mathematical Olympiad of the modern world" (Koichu & Andzans, 2009, p. 287). Founded in 1894, it was designed for students who had just graduated from secondary school; the competition consisted of three questions based on the mathematics of the secondary school curriculum. However, the competition was designed to test problem-solving ability and mathematical creativity more than factual recall. As one winner of the prize explained, "the problems are selected, however, in such a way that practically nothing, save one's own brains, can be of any help… the prize is not intended for the good boy; it is intended for the future creative mathematician" (Rado, as quoted in Wieschenberg, 1984, p. 32). Winners of the competition were awarded a monetary prize and granted automatic admission to the university of their choice. Such a reward was particularly valuable during the times of "numerus clausus" restrictions on university attendance for pupils of Jewish descent or those from the "wrong class" under communist rule. For many Hungarian students, winning such a spot may have been their only path to higher education (*D*, personal communication, 2009). From its inception, the Eötvös Competition was designed to accomplish two related goals – identification of mathematically talented students and stimulation of more creative mathematics teaching and learning (Reiman, 1997).

The prominence of this competition soon led to the development of supporting activities to help prepare students for the competition, including the publication of new types of problems each month in the journal KöMaL (*Középiskolai Matematikai és Fizikai Lapok* – the Mathematical and Physical Journal for Secondary Schools), the initiation of KöMaL's own year-long competition, and the formation of after-school "study circles" for interested students to spend additional time working on problems and practicing for the competition. Later, more competitions were founded at the school, local, regional, national, and international levels – with local competitions often serving as "feeders" into the larger, nation-wide competitions. Competitions were also established for younger students than those in secondary school, so that the students could gain experience with the competition environment prior to participation in the largest and most prestigious competitions. When the first special mathematics class was founded in 1962, students were invited to the class on the basis of their results in a local Budapest competition. In this sense, the traditional Hungarian system for educating mathematically talented students could be considered "competition-driven" – competitions were used to determine the input to the system, they drove the development of the content of the system both in the school curriculum and in supporting extracurricular activities, and competitions were used to measure the output of the system. If we take mathematical creativity to be defined as "the process that results in unusual and insightful solutions to a given problem, irrespective of the level" (Sriraman, 2008a, p. 4), then the network of mathematics competitions developed in Hungary seems to have been designed particularly to promote creativity in problem solving. The Hungarian approach served as a model for many other countries in Eastern and Central

Europe, the former Soviet Union, and for the United States (Koichu & Andzans, 2009, p. 289).

Competitions have continued to play a central role in the identification and recruitment of mathematically talented students in Hungary since the time of Eötvös. Some of the competitions for Hungarian students, such as the Kürschák and Schweitzer competitions, date back to the beginning of the 20th century. OKTV (Országos Középiskolai Tanulmányi Verseny), the "National Secondary School Academic Competition" administered by the Hungarian Ministry of Education, now holds competitions in more than 15 subjects but first began as a mathematics competition in 1923. While each competition has its own set of rules and procedures, on average a traditional Hungarian mathematics competition would consist of 3 - 6 challenging questions for students to solve individually in a time span of approximately three hours. These questions typically require a detailed proof as the solution, rather than a simple numerical answer. The results are typically scored not just on correctness but also on the quality and conciseness of the explanation, with possible additional points awarded for elegance of the proof or presentation of multiple solutions. In general, like the original Eötvös competition, most Hungarian mathematics competitions are designed to test problem solving skills and creative thinking; the goal is to identify future talented mathematicians at a young age.

One exception to this standard format among traditional competitions is the Miklós Schweitzer competition for college students, established in 1949 in memory of a young Hungarian mathematician killed during the siege of Budapest in World War II. The Schweitzer competition consists of ten questions, covering the range of topics of the classic undergraduate mathematics curriculum – analysis, algebra, combinatorics, number theory, set theory, probability theory, topology, and more. The questions are to be completed over a period of ten days, during which contestants are allowed to use any books or notes (Székely, 1996). An example question from the 2009 Schweitzer competition is given below (from Maróti, 2009):

> **7.** Let H be an arbitrary subgroup of the diffeomorphism group $\mathsf{Diff}^\infty(M)$ of a differentiable manifold M. We say that a $\mathcal{C}^\infty$ vector field X is *weakly tangent* to the group H, if there exists a positive integer k and a $\mathcal{C}^\infty$-differentiable map $\varphi :]-\varepsilon, \varepsilon[^k \times M \to M$ such that
>
> (i) for fixed $t_1, \dots, t_k$ the map
> $$\varphi_{t_1,\dots,t_k} : x \in M \mapsto \varphi(t_1, \dots, t_k, x)$$
> is a diffeomorphism of M, and $\varphi_{t_1,\dots,t_k} \in H$;
>
> (ii) $\varphi_{t_1,\dots,t_k} \in H = \mathsf{Id}$ whenever $t_j = 0$ for some $1 \le j \le k$;
>
> (iii) for any $\mathcal{C}^\infty$-function $f : M \to \mathbb{R}$
> $$Xf = \left. \frac{\partial^k (f \circ \varphi_{t_1,\dots,t_k})}{\partial t_1 \dots \partial t_k} \right|_{(t_1,\dots,t_k)=(0,\dots,0)}.$$
>
> Prove, that the commutators of $\mathcal{C}^\infty$ vector fields that are weakly tangent to $H \subset \mathsf{Diff}^\infty(M)$ are also weakly tangent to H.

As an open-book, multi-day exam, the Schweitzer competition maintains the Hungarian tradition of testing more than just regurgitation of facts (even high-level facts, as the SAT II or GRE may be said to test). The problems are not ones whose proofs are contained in standard textbooks, but rather require mathematical creativity coupled with advanced knowledge in order to solve.

New Styles of Competition

In recent years, more competitions have been developed that stray from the traditional format, such as the new Gordiusz competition and its corresponding competition for younger students, the Zrínyi competition. Unlike traditional Hungarian competitions and standardized exams, which often require written responses and detailed proofs in order to receive full credit, these two competitions have a multiple-choice format. Similar to the SAT in the United States, there is a "penalty for guessing" built in to the scoring, such that students receive 4 points for a correct answer, 0 for leaving the question blank, and lose 1 point for each wrong answer (Mategye, 2010). Although growing in popularity and easier to administer and score than traditional exams, the format still appears to be looked-down-upon by many mathematics educators within Hungary, who question the value of using multiple-choice exams to identify mathematically talented students (*J*, personal communication, 2009).

While there are too many regional competitions to describe each one, two new competitions in Budapest are presented here as examples of a new approach to competitions in Hungary: Mathematics Without Borders and the Kavics Kupa competition. Both are team-style competitions that originated outside of Hungary (Mathematics Without Borders started in France, Kavics Kupa in Italy) and were introduced in Hungarian schools by teachers who had spent time in the other country and brought back with them the idea for a new style of competition. Mathematics Without Borders was first established in 1989 and now operates in 46 countries around the world. This competition is focused on promoting mathematics as something fun, interesting, and accessible to the average student. The Hungarian branch of the competition began in 1994, and while still mostly limited to schools within Budapest, participation has increased significantly in recent years (Ökördi, 2008). In this competition, 9th grade classes compete to solve a set of 13 problems in 90 minutes. The students are responsible for organizing themselves, assigning someone to hand in the solution, deciding how to divide up the work, etc. On the day of the competition, students in all participating countries work on the same set of problems at exactly the same time. There is even a foreign language problem at the start of each competition, in which the problem is stated in a series of languages other than the students' own and they have to submit their solution in a foreign language as well. According to one of the competition organizers, the students find these features exciting and motivating, impressing on them the nature of mathematics as a field that crosses language and cultural barriers (*C*, personal communication, 2009).

It is particularly interesting to note that special mathematics classes are *not* permitted to compete (they can participate, but not receive scores or prizes). In this way, the organizers of the competition are trying to spark an appreciation of mathematics among all levels of students, and to "level the playing field" so as to keep otherwise interested but perhaps less-advanced students from becoming discouraged. By drawing on a variety of skills including mathematical talent and creativity, linguistic ability, paper folding or drawing skills, the competition offers the opportunity for all members of the class to feel they have contributed to the group's success. A few sample questions are presented below:

> 1. Peter has to read a book during his holidays. He calculates that he must read 30 pages a day to succeed. The first days of holidays, he doesn't respect the rhythm: he reads 15 pages a day. Anyway Peter thinks that he can keep this rhythm until he reaches half of the book, if he reads 45 pages of the second half every day. What do you think of the way he reasons? Explain. (Matematika Határok Nélkül, February 2009)
>
> 2. It is a dark and moonless night. Juliet, Rob, Tony, and Sophie are being chased by dangerous bandits. In order to escape they have to cross a precipice on a footbridge which is in a very bad state. It can hold the weight of two persons only. A light is absolutely needed to cross. The four friends have only got one lantern which will go out in half an hour. Juliet is quick; she can cross the footbridge in one minute. Rob needs two minutes to do that. Tony is slow: ten minutes will be necessary. Sophie is

even slower: she will need twenty minutes. If two friends cross together, they will move according to the rhythm of the slowest. The four of them managed to cross in less than thirty minutes. Explain their strategy. (Matematika Határok Nélkül, February 2008)

The shared credit of a team competition presents a very different model from the traditional Hungarian competitions, which have typically focused on individual results as a means of talent identification. The Kavics Kupa competition is another team competition, originating in Italy and first held in Hungary in 2005. Teams are formed by the students themselves, and must consist of 7 total students: at least 2 boys and at least 2 girls, no more than 3 special mathematics class students, and at least one member from each grade (9-12). The organizers have also recently started a "Little Kavics Kupa" competition for 7th and 8th grade students. Teams work together to solve 20 questions in a period of 90 minutes. Rather than requiring detailed proofs as other competitions do, the solution for each of the twenty Kavics Kupa questions is a single numerical value between 0000 and 9999 (Pataki, 2009). This format allows for on-the-spot judging – student runners submit solutions as the team progresses, with the option to resubmit again (with a slight penalty) if the first response is incorrect. Having a numerical answer rather than requiring a written proof may also be a more appropriate format for a group competition attracting multiple grade and talent levels. Topics include number theory, algebra, geometry, and logic puzzles. Some of the questions from the 2009 competition are presented below:

6.) The sum of three numbers is 0, their product is different from zero and the sum of their cubes is equal to the sum of their fifth powers. Find the one hundredth multiple of the sum of their squares. **(45 points)**

8.) For given integers n and k denote the multiple of k closest to n by $(n)_k$. Solving the simultaneous system $(4x)_5 + 7y = 15$, $(2y)_5 - (3y)_7 = 74$ on the set of integers write, as your answer, the difference $x - y$. **(30 points)**

13.) 7 dwarfs are guarding the treasure in the cellar of a castle. There are 12 doors of the treasury with 12 distinct locks on each door, making hence 144 distinct locks altogether. Each dwarf is holding some keys and the distribution of the keys secures that any three of the dwarfs are able to open all the doors. At least how many keys are distributed among the guards, altogether? **(25 points)**

15.) The lengths of the sides of the triangle ABC are whole numbers, and it is also given that $A\angle = 2B\angle$ and $C\angle$ is obtuse. Find the smallest possible value of the triangle's perimeter. **(45 points)**

These two competitions represent a significant break from tradition within the Hungarian mathematics competition system, most notably in their design as team competitions but also in the way they have been set up to intentionally limit or preclude participation by students from the special mathematics classes. Traditional competitions in Hungary have served specifically as talent identification and recruitment tools, hence the importance of awarding prizes to individuals rather than groups. The success of these early competitions then drove the development of the rest of the education system for mathematically talented students, including an extensive network of supporting extracurricular activities to help students prepare for the highest competitions.

A chart summarizing some of the major national competitions and a sampling of international and regional competitions that Hungarian students may participate in, as of 2009, is given in Table 1. The full spectrum of competitions Hungarian students may participate in is not limited to those in this chart; those listed were chosen as a representative sampling to cover the most well-known national competitions and some of the newer types developed in recent years. The chart includes the name of the competition; the date it was established; the intended grade level of participants; whether it is a local, regional, national, or international competition; and a brief overview of the format of the competition, types of questions, and scoring system. In terms of geographic region, the scope of the intended, average participant pool is listed – some competitions, such as KöMaL, while primarily national in scope, do allow international entries – but since these do not make up a significant portion of the participant pool, the competition is listed here as "national".

Table 1: Selection of Mathematics Competitions for Hungarian Students as of 2009

Competition	Est.	Grade Level	Geographic Level	Format
Kürschák (formerly Eötvös)	1894	12	National	3 questions, 5 hours; detailed proofs for solutions.
KöMaL	1894	9-12	National	Traditional section 'B': 10 questions per month, with 6 best questions scored; Also: 'K' section for 9th graders only (6 questions); 'C' section for grades 1-12 with 5 easier, practice exercises per month; 'A' section with 3 advanced problems, for Olympiad preparation. Competition runs for 9 months; solutions submitted electronically or by mail; Detailed proofs for solutions; additional points for multiple solutions.
OKTV (Országos Középiskolai Tanulmányi Verseny – "National Secondary School Academic Competition)	1923	11 & 12	National	3-5 questions in 5 hours; three categories of competition, each with their own set of questions – I. Vocational secondary school, II. Standard secondary school (non-special mathematics class), III. Special mathematics classes
Arány Daniel	1947	9 & 10	National	Three categories of competition, based on hours of mathematics per week in the students' school (with category III reserved for special mathematics classes).

Schweitzer	1949	College	National	10 questions in 10 days, open-book. Detailed proofs required for solutions.
International Mathematics Olympiad	1959	9-12	International	6 questions, 9 hours over 2 days; detailed proofs for solutions
Competition	**Est.**	**Grade Level**	**Geographic Level**	**Format**
Kalmár László	1971	3-8	National	3^{rd} & 4^{th} grade: 6 questions. 5^{th} & 6^{th} grade: 4 questions. 7^{th} & 8^{th} grade: 5 questions. Different set of questions per grade; written answer with explanation required for solution.
Varga Tamás	1988	7-8	National	Three rounds of competition: school, county, & national. 5 questions in 2 hours, per round. Two categories per grade, based on number of hours of mathematics per week.
Hungary-Israel Olympiad	1990	9-12	Bi-national	6 questions over a period of 2 days (similar to IMO format).
Abacus	1994	3-8	National	Journal competition, similar to KöMaL.
Gordiusz	1994	9-12	National	Multi-round competition leading up to national final. 30 multiple choice questions in 90 minutes.
Mathematics Without Borders	1994	9^{th}	International / Local	Teams are whole 9^{th} grade classes (special mathematics classes may not compete); 13 questions in 90 minutes.
Zrínyi Ilona	1994	3-8	National	Multi-round competition leading up to national final. 3^{rd} & 4^{th} grade: 25 multiple choice questions in 60 minutes. 5^{th} & 6^{th} grade: 25 multiple choice questions in 75 minutes. 7^{th} & 8^{th} grade: 30 multiple choice questions in 90 minutes.
Kavics Kupa	2005	9-12	Local	20 questions in 90 minutes for a team of 7 students; solutions are numerical values.
Middle European	2007	9-12	International	Day 1: Individual competition (4

Mathematical Olympiad				questions in 5 hours). Day 2: Team competition (8 questions in 5 hours). Detailed proofs required for solution.

Competitions and Education

Competitions and their historical legacy also serve as a key source of curricular material for teachers and students; published compilations of competition problems are widely used throughout Hungary, both in classrooms and in study circles or camps focused on preparing for future competitions. More recently, a number of internet resources have been developed, providing students and teachers with searchable databases of problems going back more than 100 years. In fact, the widespread availability and active use of older problems has had an impact both on the mathematical curriculum in Hungary and on the competitions themselves. As students have access to more resources and spend more time specifically preparing for these competitions, it becomes increasingly difficult to generate new, challenging problems that have not been used in previous competitions. (*D,* personal communication, 2009).

> 30 years ago a problem appeared at the Kürschák competition for high school graduates, and now the same question can be given to 12 year olds. So certain mathematical ideas are much more widespread on one hand, and students are familiar with them at a much younger age. (*E*, personal communication, 2009)

In general, the number of mathematics competitions in Hungary continues to rise. According to one interviewee, this may be in part because of the restriction on establishing any new special mathematics classes; as a result, motivated teachers who want to provide some outlet for talented and creative students will now develop a competition for their school or region instead (*E*, personal communication, 2009). The emergence of new types of competitions in Hungary that are specifically designed to downplay the participation of the most talented students also raises some questions about the value of traditional competitions. Are they perceived as being too stressful for students? Are they no longer successful means of identifying and recruiting talented students? Perhaps the changing competition styles emphasizing teamwork over individual achievement reflect a transition in the cultural values within Hungarian education – one downside to a system with such a tradition of excellence is the potentially exclusive atmosphere established around those highly-selective programs. While the selection and encouragement of individual talents continues, these new team competitions have a different purpose – their goal is to make mathematics exciting and accessible for the average Hungarian student. Organizers of both traditional and new mathematics contests cite the motivating power of competitions and the value they add to the mathematics education system by promoting student interest and involvement in mathematics (*A*, personal communication, 2009).

However, participating in competitions is not necessarily a positive experience for all students. Some teachers mentioned the potential damaging power of a competition if a student receives a poor result and interprets that to mean he or she should not continue to pursue mathematics, as well as the risk that a student could "burn out" from the stress of too many competitions. Other concerns include the potential failure to identify mathematically talented students if their talents do not align well with the structure of the competitions (Reiman, 1997, p. 8). One interviewee highlighted an additional concern about the emphasis placed on competitions in Hungary, which was that it created a cultural expectation about the nature of mathematics that does not line up with the requirements of advanced mathematics study at the college level and beyond:

> So (for regular competitions) you must be very creative, very ingenious, very well prepared, very quick! But this is a false aspect of mathematics. So you should leave it behind before developing wrong habits. Mathematical ability can be exercised by study. This is something which must be the college experience, by the way, but here [in Hungary] they kind of overload the kids with very intensive mathematical experience for the younger generation. It's kids' play to be busy with math competitions. Just it is so trendy or this is everywhere… it is just a narrow aspect of mathematics. And there is a devaluation of [studying mathematics]… it has an effect on the image on what's happening in math classes in Hungary. Because if you enter a math class, what do you find? Solving problems. Problem solving can mean you solve a quadratic equation or that you are thinking of an IMO problem. You ask a student what is a mathematician doing? "solving problems". But this is just… it is a very important aspect of mathematics, but studying mathematics, mathematization, how do you evolve a theorem, is missing. It's almost exclusively problem solving on various levels, in Hungary. (*E*, personal communication, 2009)

Despite these concerns over the apparent trivialization of mathematics that competitions may present, researchers have identified problem solving as the aspect of mathematics most directly related to the activity of research mathematicians and stress its importance in the development of mathematical talent (Pólya, 1988; Schoenfeld, 1983; Sriraman, 2008b; Sternberg, 1996). Although there may be growing discomfort with the competition-driven mindset of the Hungarian mathematics education system and concern that it is becoming too much of a "sport" rather than studying mathematics, the continued emergence of new contests suggests that competition itself remains a key way to engage students and motivate their interest in mathematics. The founding of team competitions and competitions for students from outside the special mathematics classes reflect a possible shift in the focus and purpose of competitions away from a strictly talent-search model to a more inclusive "enrichment" approach. There remains one competition, however, which must be considered in a separate category from all the rest. It emphasizes careful thinking and stamina over speed, lasting an entire school year rather than a few hours. This is the competition run by the journal KöMaL.

KöMaL

KöMaL is a journal for secondary school students (and teachers) published once a month throughout the academic year. It includes articles by teachers and mathematicians about new, interesting topics in mathematics; a series of mathematics problems for students to solve; and the results from other national and international competitions along with a sampling of problems and their solutions. There are sections on physics and informatics as well. The KöMaL journal and competition have played a significant role in the development of mathematically talented students in Hungary over the past century, in no small part because of the prominence of previous winners:

> This can be stated for sure: Almost everyone who became a famous or nearly famous mathematician in Hungary, when he or she was a student, they took part in this contest. I actually personally do not know anyone among them who would be a counterexample to that statement.
> (Peter Hermann, KöMaL editor, in Webster, 2008)

KöMaL's competition differs from the typical mathematics competitions because it is not a single, timed event, but rather takes place over the course of an entire school year. New problems are published each month, and students have until the middle of the next month to submit their solutions. The best solutions are published in the following issue. Students accrue points over the course of the year and the winners are announced in August. Since 2000, KöMaL has operated under its current format, which offers four separate mathematics competitions: K, C, B, and A. The K section is a joint contest with their partner journal, ABACUS, offered for 9th grade students only, and consists of 6 questions per month. The C contest was established in 1984 to provide a forum for students from outside the special mathematics classes and for younger students just getting started in problem-solving competitions; this contest has five easier, so-called "practice" exercises each month. Special mathematics class students are encouraged not to compete in this section, but rather in the B section, which is KöMaL's traditional competition. The B competition publishes ten questions per month; students can submit as many solutions as they like but only the top six are scored. An additional, newer section is the A competition, started in 1993, which has three advanced problems each month. These problems are designed for students who are preparing for the IMO or other high-level mathematics competitions. A few questions from the February 2010 competition, highlighting the differences between the four levels of competition, are included below:

A. 501. Let $p > 3$ be a prime. Determine the last three digits of $\sum_{i=1}^{p}\binom{i\cdot p}{p}\binom{(p-i+1)p}{p}$ in the base-p numeral system. (5 points)

(Based on the proposal of *Gábor Mészáros,* Kemence)

A. 502. Prove that for arbitrary complex numbers $w_1, w_2, \ldots, w_n$ there exists a positive integer $k \le 2n + 1$ for which $\mathrm{Re}(w_1^k + w_2^k + \ldots + w_n^k) \ge 0$. (5 points)

B. 4242. Is there an n, such that it is possible to walk the $4 \times n$ chessboard with a knight touching each field exactly once so that with a last step the knight returns to its original position? What happens if the knight is not required to return to the original position? (4 points)

B. 4247. Two faces of a cube are *ABCD* and *ABEF*. Let *M* and *N* denote points on the face diagonals *AC* and *FB*, respectively, such that *AM*=*FN*. What is the locus of the midpoint of the line segment *MN*? (3 points)

B. 4251. Let $p > 3$ be a prime number. Determine the last two digits of the number

$$\sum_{i=1}^{p}\binom{i\cdot p}{p}\binom{(p-i+1)p}{p}$$

written in the base-p numeral system. (5 points)

(Based on the proposal of *Gábor Mészáros,* Kemence)

C. 1020. The members of a small group of representatives in the parliament of Neverland take part in the work of four committees. Every member of the group works in two committees, and any two committees have one member in common from the group. How many representatives are there in the group? (5 points)

C. 1021. *P* is a point on side *AC*, and *Q* is a point on side *BC* of triangle *ABC*. The line through *P*, parallel to *BC* intersects *AB* at *K*, and the line through *Q*, parallel to *A*C intersects *AB* at *L*. Prove that if *PQ* is parallel to *AB* then *AK*=*BL*. (5 points)

K. 241. The road from village *A* to village *B* is divided into three parts. If the first section were 1.5 times as long and the second one were 2/3 as long as they are now, then the three parts would be all equal in length. What fraction of the total length of the road is the third section? (6 points)

K. 246. Four different digits are chosen, and all possible positive four-digit numbers of distinct digits are constructed out of them. The sum of the four-digit numbers is 186 648. What may be the four digits used? (6 points)

Hungarian IMO team leader István Reiman highlighted the value KöMaL provides in preparing students for advanced mathematics work as well:

> The journal plays two main roles: it helps close the gap between mathematics and physics in the real world and that taught in school, and it also serves to awaken the students' interest. From the point of view of the Olympiads, the journal is most helpful in teaching the students how to write mathematics correctly. (Reiman & Gnädig, 1994, p. 17)

As László Miklós Lovász, son of Fields Medalist László Lovász, described, "in KöMaL, it matters how hard working you are. Some people are very good at competitions, but too lazy to do KöMaL. So it's very close to what a mathematician does, as far as I can tell" (in Webster, 2008). The connection between the KöMaL competition and professional mathematics can also be understood in the context of Renzulli's three-ring model of giftedness: the challenging questions attract students with above-average intellectual ability; both the untimed and multi-month nature of the competition require significant levels of task commitment; and the awarding of extra points for submitting multiple solutions to the same problem promotes mathematical creativity (Renzulli, 1979).

In the online introduction for *C2K: Century 2 of KöMaL* (1999), one of KöMaL's special English-language issues, the editor shares a particularly appropriate story about the value of tradition:

> There is a joke about an American visitor, who, wondering about the fabulous lawn of an English mason asks the gardener about the secret of this miracle. The gardener modestly reveals that all has to be done is daily sprinkling and mowing once a week.
> - So very simple?
> - Yes. And after four hundred years you may have this grass.
>
> (Berzsenyi)

In fact, the story of the English gardener reflects not just the more than 100 year heritage of KöMaL, but also the value of engaging in mathematics on a regular, sustained basis, which is one of the key features of the KöMaL competition. The long duration and continuous effort required make the KöMaL competition quite different from other national and international competitions, and also make it one of the cornerstones of Hungary's approach to encouraging and identifying mathematically talented students. As Csapo pointed out in *Math Achievement in Cultural Context: The Case of Hungary* (1991), the expectation of success based on previous success has created a kind of self-fulfilling prophecy in Hungarian mathematics education. In other words, the tradition of excellence breeds excellence.

Conclusion

Competitions have always played a central role in the Hungarian mathematics education system for talented students, but the nature of that role is changing. Traditional competitions, such as the Kürschák, Schweitzer, and KöMaL competitions, are attracting fewer participants. This may be because winning these competitions is no longer quite as meaningful as it once was. In the past, winners were granted automatic admission to the university of their choice; this was a highly valuable prize during the Communist regime when there were a number of restrictions on admission, but is perhaps a less relevant prize in the present system. New types of competitions have been developed in recent years, including multiple choice exams and team competitions, numerous school and local competitions, and competitions for students of all ages and ability levels. This variety may explain another reason for the decline in participation rates of some of the competitions - there are now many more competitions but the same number of contestants (or fewer[2]) to go around. Still, talented students seem to be participating in as many, if not more, competitions than students did 20 or 40 years ago. Given that the Hungarian ranking system for secondary schools depends largely on students' competition results, it is clear that competitions remain an integral part of the Hungarian mathematics education system. It is clear that in Hungary, tradition itself remains a strong motivating factor and continues to stimulate the development of mathematically talented students.

[2] Demographic trends in Hungary indicate a decreasing number of school-age children

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